Journal of the Royal Society of Western Australia, Vol. 69, Part 3, 1987, p. 113-116.

Rb-Sr Geochronology of granitoids from Mount Mulgine, Western Australia

by J. R. De Laeter and J. L. Baxter

School of Physics and Geosciences, Curtin University of Technology, Bentley, Western Australia, 6102.

Manuscript received 15 July 1986; accepted 16 December 1986

Abstract

The Mulgine Granite is highly fractionated with greisen sheets containing tungsten-molybdenum mineralisation. The Mulgine Granite forms a dome-shaped body which has been intruded by an unmineralised discordant porphyritic-biotite adamellite.

The best estimate of the Rb-Sr whole rock age and initial $^{87}Sr/^{86}Sr$ ratio of the Mulgine Granite is 2684 ± 79 Ma and 0.701 ± 0.005 respectively. It is unlikely that it had an extended crustal pre-history. The cross-cutting porphyritic-biotite adamellite has a Rb-Sr whole rock age of 2596 ± 35 Ma with an initial $^{87}Sr/^{86}Sr$ ratio of 0.704 ± 0.004. Although the experimental errors do not show a significant difference in the ages, the isotopic data indicate that the porphyritic-biotite adamellite is younger than the Mulgine Granite: a result consistent with the field relationships. A subset of the samples of the porphyritic-biotite adamellite gives an approximate Rb-Sr whole rock age of 2330 Ma and an initial $^{87}Sr/^{86}Sr$ ratio of 0.713. Two Rb-rich samples of granitoid from the Mulgine Granite give similiar model Rb-Sr ages which indicate that a later thermal event has affected both granitoid suites.

Introduction

The Yilgarn Block in Western Australia is one of the largest segments of Archaean crust in the world. Gee *et al.* (1981) subdivided the Yilgarn Block into three granitoid-greenstone provinces (the Murchison, Southern Cross and Eastern Goldfields provinces), and a predominantly gneissic terrain (the Western Gneiss Terrain), which occupies an area around the western periphery of the granitoid-greenstone province.

Granitoids account for about 70 per cent of the crustal exposure of the Yilgarn Block, which has an area of approximately 650,000 km^2 (Gee *et al.* 1981). Older synkinematic granitoids have been described by Archibald and Bettenay (1977) and Watkins and Tyler (1985) in the Kalgoorlie and Cue districts of the Yilgarn Block respectively. Younger post-tectonic granitoid batholiths intrude these foliated rocks.

The most common compositional types in both synkinematic and post-tectonic plutons are adamellite and granodiorite in contrast to many other granitoid-greenstone terrains where more tonalite and trondjemitic rocks predominate (Libby 1979).

In the Murchison Province the greenstone belts are intruded by a number of discrete or coalescing ovoid plutons (Muhling 1969). The synkinematic granitoids are emplaced prior to deformation and metamorphism within the greenstone belts (Watkins and Tyler 1985), each commonly containing co-planar foliation. Deformation and metamorphism in the synkinematic granitoids and greenstone belts are consequently often co-eval.

From an extensive Rb-Sr whole-rock study of granitoids and gneisses across most of the Yilgarn Block, Arriens (1971) found three distinct episodes between 3100-2900 Ma, 2700-2550 Ma and 2300-2200 Ma. Arriens pointed out that many of the granitoids which had Rb-Sr ages between 2700 and 2600 Ma have an initial $^{87}Sr/^{86}Sr$ ratio of approximately 0.704 suggesting a crustal pre-history for these samples. Arriens (1971) estimated that these granitoids could not have existed for longer than 120 Ma as crustal materials, assuming an average Rb/Sr ratio for the granitoids of 0.85. However, Gee *et al.* (1981) argue that this period of crustal prehistory may be 200 to 400 Ma in duration. Oversby (1975) considers that the high μ values recorded in some Eastern Goldfields granitoids indicates that these rocks had existed as crustal material for at least 300 Ma before the ~ 2600 Ma tectono-thermal event. On the other hand Bickle *et al.* (1983) argue that Pb-Pb whole rock isotopic data from synkinematic plutons in the Diemals area indicate that the crustal history of the precursor material is less than ~ 200 Ma.

De Laeter *et al.* (1981a) have reviewed the geochronological data in the Yilgarn Block. Few results from the Murchison Province have been reported. Granitoids from the Cue-Mount Magnet-Paynes Find region give a Rb-Sr whole-rock age of 2706 ± 264 Ma (Arriens 1971). Two muscovites from Mount Mulgine give model Rb-Sr ages of 2632 and 2614 Ma (Arriens, 1971). Muhling and De Laeter (1971) also reported Rb-Sr whole-rock ages for granite-adamellite and granodiorite from the Poona batholith (a complex granitoid body east of Cue), of 2535 ± 23 Ma and 2550 ± 51 Ma respectively. Fletcher (Pers. Comm.) has obtained Sm-Nd model ages of 2820 Ma and 2730 Ma on two of these samples.

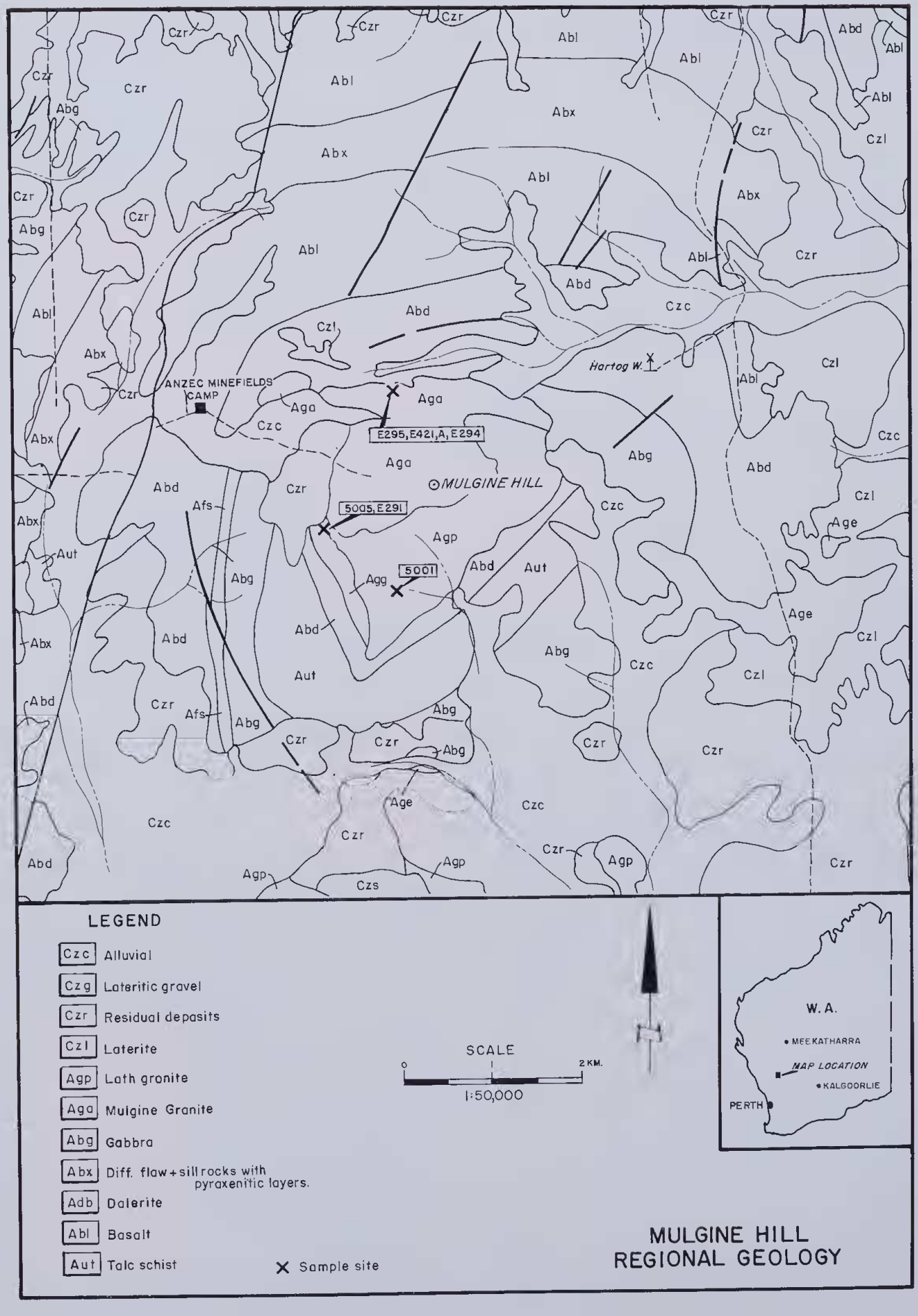

Figure 1.—Regional map of Mount Mulgine in the Murchison Province of Western Australia.

Geology of the area

The Mt. Mulgine district contains a mafic volcanic supracrustal succession intruded by the synkinematic Mulgine Granite and a discordant porphyritic (lath granite) adamellite (Fig. 1). Both granitoid suites are unusually highly fractionated with Rb-Sr ratios ranging from 0.88 to 49.5.

The Mulgine Granite is a 1 km diameter ovoid stock near the axis of a regional anticline. The northern, eastern and western margins of the stock are parallel to layering in the adjacent volcanic sequence (Baxter 1979). Foliation and lineation in the volcanic rocks and the granite are parallel. Greisen sheets intrude the volcanic sequence along the northern perimeter of the stock. The greisen has induced polymetallic scheelite-molybdenite-fluorite mineralisation in potassium metasomatized ultramafic rocks in the adjacent volcanic sequence. Pegmatites and greisen sheets associated with the Mulgine Granite occur up to 2 km from the stock contact. The volatile rich nature of the Granite is indicated by the wide halo of hydrothermal alteration around the stock.

Porphyritic-biotite adamellite intrudes the southern margin of the Mulgine Granite (Fig. 1). This is an apophysis of a batholith of coarse-grained porphyritic and even-grained adamellite lying to the south and east of Mulgine Hill.

Experimental procedures

Samples were reduced to -200 mesh using a jaw crusher and an agate Tema-type mill. After chemical extraction, the samples were analysed in a 30.5 cm radius of curvature, 90° magnetic sector field, solid source mass spectrometer. Techniques are essentially those reported by De Laeter *et al.* (1981b).

The value of $^{87}Sr/^{86}Sr$ for the NBS 987 standard was 0.7102 ± 0.0001 normalised to a $^{87}Sr/^{86}Sr$ value of 8.3752. A value of $1.42 \times 10^{-11} yr^{-1}$ was used for the decay constant of ^{87}Rb. All the Rb-Sr ages quoted in this paper have been corrected where necessary, to this decay constant. The data have been regressed using the least squares programme of McIntyre *et al.* (1966). All errors are given at the 95% confidence level.

Results and discussion

Two suites of samples were available for analysis—the Mulgine Granite and the postkinematic discordant porphyritic-adamellite. Isotopic data are listed in Tables 1 and 2 for these two granitoids.

Mulgine Granite

Initially nine samples of the Mulgine Granite were collected and subsequently analysed. Seven of the nine samples form an isochron with an age of 2694 ± 30 Ma and initial $^{87}Sr/^{86}Sr$ ratio (R_i) of 0.7000 ± 0.0018 (Fig. 2). The mean square of weighted deviates (MSWD) is 6.3, indicating that there is a real dispersion in the data greater than the experimental errors associated with the measurements. A better estimate of the age, initial ratio and associated errors is 2684 ± 79 Ma and R_i = 0.7007 ± 0.0053. This Model 4 age implies a real scatter in age and initial ratio. Taking into account the average Rb/Sr ratios of these samples, it is unlikely that there was an extended period of crustal pre-history for these samples. The remaining two samples (numbers 255 and 247) have a much higher Rb/Sr ratio with respect to the group, and give model ages of 2362 Ma and 2282 Ma respectively. The choice of initial ratio does not affect the model ages to any significant extent.

Subsequently, another five drill-core samples of the Mulgine Granite were obtained, and if these are combined with the original seven samples, a Rb-Sr whole rock age of 2644 ± 17 Ma and R_i = 0.7026 ± 0.0012 is obtained with a MSWD of 28. Thus the effect of the additional samples is to increase the scatter in the data, and to lower the age slightly. A Model 2 assessment of the age, initial ratio and errors is 2643 ± 87 Ma and R_i = 0.7026 ± 0.0061 respectively.

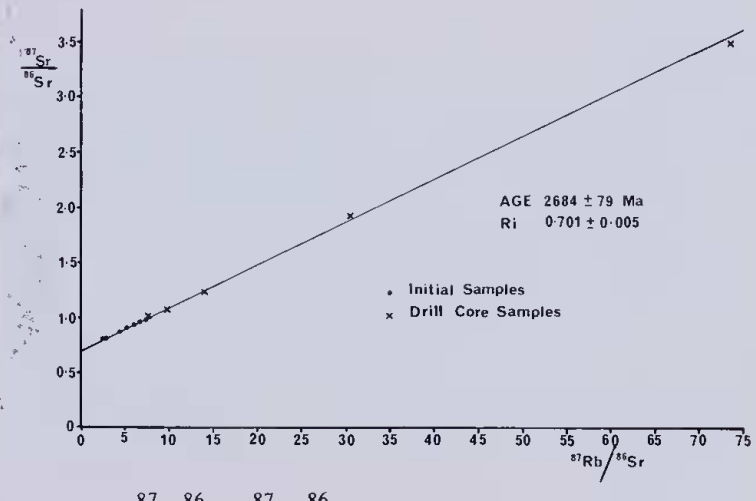

Figure 2.—$^{87}Sr/^{86}Sr$ vs $^{87}Rb/^{86}Sr$ isochron diagram for the Mount Mulgine Granite.

It is of interest to note that the average age for the two muscovite samples reported by Arriens (1971) is 2623 Ma. These two samples, presumably from pegmatites associated with the Mulgine Granite, were obtained from drill-core by Newmont Pty Ltd, who held leases for molybdenum prospecting at Mount Mulgine. The Rb/Sr values for these muscovites are exceptionally high.

Porphyritic Adamellite

Ten samples of the porphyritic-biotite adamellite were originally analysed and the results are displayed in Figure 3. Six of the ten samples fall on an isochron of age 2570 ± 65 Ma and R_i = 0.7055 ± 0.0071 with a MSWD

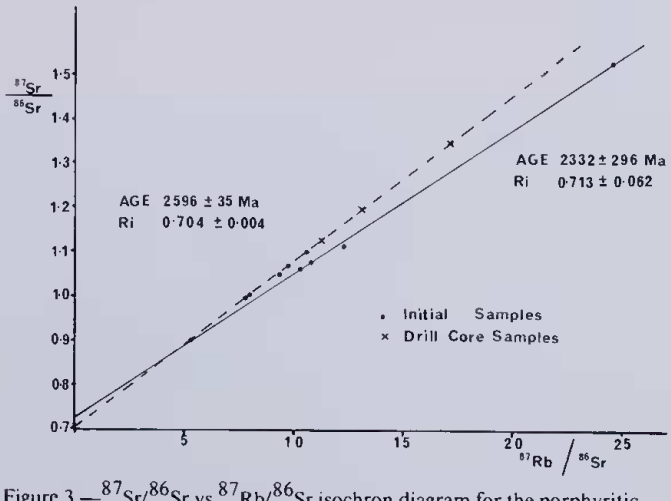

Figure 3.—$^{87}Sr/^{86}Sr$ vs $^{87}Rb/^{86}Sr$ isochron diagram for the porphyritic-biotite granitoid from Mount Mulgine.

of 2.4. Subsequently three additional samples were analysed, and if the resulting nine samples are fitted to an isochron, an age of 2596 ± 35 Ma and R_i = 0.7039 ± 0.0043, with an improved MSWD of 1.8 is obtained.

The remaining four samples (numbers 270, 266, 267 and 271) give a poorly fitted isochron with a Model 3 age and initial ratio of 2332 ± 296 Ma and 0.7133 ± 0.062 respectively. This age, despite its large error, is in good agreement with the average model age 2322 Ma, of samples 255 and 247 from the Mulgine Granite.

Conclusion

The Rb-Sr whole rock analyses of two suites of granitoids from the Mount Mulgine district indicate that the Mulgine Granite is older than the discordant porphyritic-biotite adamellite, thus supporting the field relationships. The low initial ratio of the Mulgine Granite suggests that the rocks were derived from the mantle, with a relatively short crustal history prior to the Rb-Sr isochron age. The best estimate of this whole-rock age is 2684 ± 79 Ma with an initial ratio of 0.701 ± 0.005. However if one takes into account all the isotopic evidence available, it could be argued that an age of approximately 2650 Ma and an initial ratio of 0.702 is more appropriate for the Granite.

The discordant porphyritic biotite adamellite gives a younger age of 2596 ± 35 Ma with an initial ratio of 0.704 ± 0.004. In terms of the errors associated with the two sets of samples, it is not possible to state that the ages and initial ratios are significantly different, although the isotopic data are consistent with the field evidence.

A subset of the porphyritic adamellite suite gave an approximate age of 2330 Ma with a high initial ratio of 0.713. This younger age is in good agreement with model ages from two Rb-rich samples from the Mulgine Granite, and reflects a younger Proterozoic metamorphic event which has reset some of the samples from each granitoid suite. It is possible that this event could be associated with the basic magmatic emplacement of Proterozoic dykes in the Yilgarn Block.

Acknowledgements—

This project was proposed by Associate Professor D. I. Groves of the Geology Department of the University of Western Australia, who also commented on an earlier draft of this manuscript. Initial field work and sample collection was carried out by Mr F. D. Turner, under the supervision of Associate Professor Groves. The authors would like to thank Dr K. Watkins, Mrs P. R. Harris, Mr E. Schmidt and Mr D. J. Hosie for their assistance. This project was supported by the Australian Research Grants Committee.

References

Archibald, N. J. and Bettenay, L. F. (1977).—Indirect evidence for tectonic reactivation of a pre-greenstone sialic basement in Western Australia *Earth Planet. Sci. Lett.*, **33**: 370-378.

Arriens, P. A. (1971).—The Archaean Geochronology of Australia. *Spec. Publ. Geol. Soc. Aust.*, **3**: 11-23.

Baxter, J. L. (1979).—Molybdenum, tungsten, vanadium and chromium in Western Australia. *West. Aust. Geol. Survey. Min. Res. Bull.*

Bickle, M. J., Chapman, H. J., Bettenay, L. F., Groves, D. I. and De Laeter, J. R. (1983).—Lead ages, reset Rb-Sr ages and implications for the Archaean Crustal Evolution of the Diemals area, Central Yilgarn Block, Western Australia. *Geochim. Cosmochim. Acta*, **47**: 907-914.

De Laeter, J. R., Libby, W. G. and Trendall, A. F. (1981a).—The older Precambrian Geochronology of Western Australia. *Spec. Publ. Geol. Soc. Aust.*, **7**: 145-157.

De Laeter, J. R., Williams, I. R., Rosman, K. J. R. and Libby, W. G. (1981b).—A definitive 3350 Ma age from banded gneiss, Mount Narryer area, Western Gneiss Terrain. *West Aust. Geol. Surv. Ann. Rept.* 1980: 94-98.

Gee, R. D., Baxter, J. L., Wilde, S. A. and Williams, I. R. (1981).—Crustal development in the Archaean Yilgarn Block, Western Australia. *Spec. Publ. Geol. Soc. Aust.*, **7**: 43-56.

Libby, W. G. (1979).—Reginnal variation in granitic rock. *Report Geol. Surv. West. Aust.*, **9**: 53-109.

McIntyre, G. A., Brooks, C., Compston, W. and Turek, A. (1966).—The statistical assessment of Rb-Sr isochrons. *J. Geophys. Res.*, **71**: 5459-5468.

Muhling, P. C. (1969).—The geology of the granitic rocks of the Poona-Dalgaranga area, Murchison and Yalgoo Goldfields *West. Aust. Geol. Surv. Ann. Rept.* 1968: 50-52.

Muhling, P. C. and De Laeter, J. R. (1971).—Ages of granitic rocks in the Poona-Dalgaranga area of the Yilgarn Block, Western Australia. *Spec. Publ. Geol. Soc. Aust.*, **3**: 25-31.

Oversby, (1975).—Lead isotope systematics and ages of Archaean acid intrusives in the Kalgoorlie-Norseman area, Western Australia. *Geochim. Cosmochim. Acta*, **39**: 1107-1125.

Watkins, K. P. and Tyler, I. M. (1985).—Structural and stratigraphic relationships in the Archaean granite-greenstone terrain around Cue, W.A. *West. Aust. Geol. Surv. Rept.* **14**: 46-56.